# Executive Summary

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## Introduction

Lawrence Livermore National Laboratory (LLNL), a U.S. Department of Energy (DOE) facility operated by the University of California, serves as a national resource of scientific, technical, and engineering capability. The Laboratory's mission focuses on nuclear weapons and national security, and over the years has been broadened to include areas such as strategic defense, energy, the environment, biomedicine, technology transfer, the economy, and education. The Laboratory carries out this multifaceted mission in compliance with local, state, and federal environmental regulatory requirements. It does so with the support of the Environmental Protection Department, which is responsible for environmental monitoring and analysis, hazardous waste management, environmental restoration, and ensuring compliance with environmental laws and regulations.

LLNL comprises two sites: the Livermore site and Site 300. The Livermore site occupies an area of 3.28 square kilometers on the eastern edge of Livermore, California. Site 300, LLNL's experimental testing site, is located 24 kilometers to the east in the Altamont Hills, and occupies an area of 30.3 square kilometers. Environmental monitoring activities are conducted at both sites as well as in surrounding areas.

This summary provides an overview of LLNL's environmental activities in 1994, including radiological and nonradiological sampling and surveillance monitoring, remediation, assessment of radiological releases and doses, and determination of the impact of LLNL operations on the environment and public health.

## Environmental Monitoring Results

During 1994, the Environmental Protection Department sampled air, sewage effluent, ground water, surface water, soil, vegetation and foodstuffs, and measured environmental radiation. More than 17,200 environmental samples were taken and 21,500 analyses conducted for more than 236,000 analytes. The last number compares to 190,000 for the previous year.

LLNL's sampling networks undergo constant evaluation; changes are made, as necessary, to ensure adequate, cost-effective monitoring of all media potentially affected by LLNL operations. Once samples are collected, they are analyzed for radioactive and nonradioactive substances using standard methods such as analytical procedures approved by the U.S. Environmental Protection Agency (EPA), special systems such as the continuous monitoring system for Livermore

site sewage, or special analytical techniques designed to measure very low levels of radionuclides. Environmental radiation is also measured directly using dosimeters.

The amount of radioactivity released from LLNL during 1994 was slightly less than in 1993 and was below the range of earlier years. The most significant radiological effluent for the Livermore site continues to be tritium, the radioactive isotope of hydrogen. The primary source of tritium emissions is Building 331, the Tritium Facility. Routine Livermore site operations released a total of $5.1 \times 10^{12}$ Bq (137 Ci) of tritium to the atmosphere in 1994; of that, $2.8 \times 10^{12}$ Bq (77 Ci) was in the form of tritiated water. In 1993 the total emissions were $8.77 \times 10^{12}$ Bq (177 Ci). By contrast, levels of tritium emissions in 1991 and previous years were above $37 \times 10^{12}$ Bq (1,000 Ci). The Tritium Facility has significantly reduced its tritium operations except for inventory reduction and cleanup activities. Tritium values measured in surface water, rainwater, and runoff were low in 1994, comparable to levels the previous year and consistent with a generally decreasing historical trend. Measured values for tritium in air and vegetation in 1994 were not statistically different from those in 1993.

At Site 300, the dominant radioactive effluent is depleted uranium, which contains isotopes with atomic weights 238, 235, and 234 in the weight percentages 99.8, 0.2, and 0.0005, respectively. The primary sources of these emissions were experiments on the firing tables adjacent to Buildings 801 and 851, resulting in estimated releases of $2.8 \times 10^{9}$ Bq ($7.6 \times 10^{-2}$ Ci), $3.6 \times 10^{7}$ Bq ($9.7 \times 10^{-4}$ Ci), and $2.6 \times 10^{8}$ Bq ($7.1 \times 10^{-3}$ Ci) for the three isotopes, respectively. These emissions are a little more than twice those in 1993 but within the range of variation seen from year to year due to changes in the level of operations at the firing tables.

To determine whether Site 300 operations are affecting the measured levels of uranium, we analyzed the ratio of uranium-238 to uranium-235. Natural uranium contains uranium-238, -235, and -234 in the weight percentages 99.274, 0.72, and 0.0057. The observed ratio of the 238 and 235 isotopes, therefore, can reveal whether LLNL operations have added uranium-238 to the environment at Site 300. The ratios of airborne particulate uranium deviated from the natural ratio during two months (October and December) of 1994, indicating the presence of airborne uranium-238 from Site 300 operations. The measured concentrations of uranium-238, however, are only a small fraction (16/100,000) of the regulatory exposure guideline of 0.03 $\mu g / m^3$.

Particulate matter in air is monitored for beryllium and for radionuclides, including plutonium and uranium isotopes. Most of the radioactivity detected is from naturally occurring radionuclides and global fallout from historical nuclear weapons testing by the world's nuclear powers. Plutonium from fallout and past

programmatic activity is found at low levels around the perimeter of the Livermore site. Plutonium from fallout only is detected at even lower levels at Site 300. The highest average plutonium value was measured at a location on the Livermore site near Building 531. The median concentration there was $1.7 \times 10^{-13}$ Bq / mL of air ($4.5 \times 10^{-24}$ Ci / mL), a small fraction (23 / 100,000) of the regulatory exposure guideline of $7.4 \times 10^{-10}$ Bq / mL of air ($2 \times 10^{-20}$ Ci / mL).

A special study of plutonium in Big Trees Park in the City of Livermore began in 1994. During a 1993 EPA investigation of plutonium in soils in the southeast quadrant of the Livermore site, EPA personnel collected a soil sample at Big Trees Park about two kilometers to the west to serve as a background sample. This soil sample showed plutonium at higher concentration than expected from global fallout for this region. The park was resampled by EPA, LLNL, and the California Department of Health Services (DHS). The results confirmed the finding of plutonium, but all results are below the EPA's preliminary remediation goal for residential exposure to plutonium. The EPA and DHS concur that there is no regulatory concern or significant impact on human health or the environment.

Discharges of radioactive and hazardous materials to the combined sanitary and industrial sewer at the Livermore site are controlled by limiting the use of those materials, implementing engineering controls, and routing discharged material to retention tanks for later characterization and treatment. Flow-proportional samples of discharged wastewater are regularly collected and analyzed to assure that LLNL's sewage effluent meets the requirements of the permit granted by the City of Livermore. In addition, effluent is monitored continuously for pH, selected metals, and radioactivity. Should concentrations be detected above warning levels, LLNL's sewer diversion system is automatically activated. The diversion system captures all but the first few minutes of wastewater flow that causes an alarm, thereby protecting the Livermore Water Reclamation Plant (LWRP) and minimizing any required cleanup. In 1994, there were two releases, involving methylene chloride and zinc, that slightly exceeded discharge limits for release of materials to the sanitary sewer system. The results of the effluent monitoring program demonstrate the success of LLNL's discharge control programs.

Water sampling and analysis are a large part of the LLNL surveillance monitoring effort. The waters monitored include lakes, streams, rainfall, tap water, storm water runoff, drinking water-supply wells, and ground water monitoring wells. The samples are analyzed for gross alpha and gross beta radiation, tritium, and nonradioactive pollutants, including solvents, metals, and pesticides. Median activities for gross alpha and gross beta radiation in surface water samples for the Livermore site and Livermore Valley in 1994 were less than 10% of the drinking water maximum contaminant level (MCL). Storm

water gross alpha and gross beta were well below MCLs, with the exception of samples collected November 5 at one location (GRNE) that is upstream and off the Livermore site. The origin of the elevated readings has not been determined. Livermore site rainfall has exhibited elevated tritium activities in the past, but during 1994, measurements were far below the 740 Bq/L (20,000 Ci/L) MCL established by the EPA for drinking water; the highest activity measured was 12% of the MCL. Tritium values for surface and drinking water samples were less than 1% of the drinking water standard.

The Ground Water Protection Management Program at LLNL is a multifaceted effort to eliminate or minimize adverse impacts of Laboratory operations on ground water. It also aims to determine the extent and understand the impact of past activities, remediate adversely affected areas, and monitor current operations. Ground water monitoring at the Livermore site investigates contamination according to the Federal Facility Agreement for the Comprehensive Emergency Response, Compensation, and Liability Act (CERCLA). LLNL conducts ground water monitoring at Site 300 under three programs: one to meet regulatory commitments established for site-specific CERCLA investigations, a second consisting of routine compliance monitoring around landfill and wastewater surface impoundment units, and a third to perform surveillance monitoring in and around the site to register the impacts, if any, of current operations.

LLNL routinely monitors ground water wells in the Livermore Valley and at Site 300, to complement the extensive CERCLA monitoring activities associated with known areas of ground water contamination. Tritium, as well as other radioisotopes and a wide range of inorganic and organic constituents of potential concern, are measured. Tritium measurements in 21 wells in the Livermore Valley all showed very low values compared to the EPA MCL for drinking water; the highest measured value was 15.7 Bq/L (424 pCi/L), which is approximately 2% of the standard (occurring in a nondrinking water source). The overall trend of tritium is downward in Livermore Valley ground waters; the mean tritium activity in these wells has declined more than 50% in the past six years. The principal processes causing this decline are the natural decay of tritium (12.3-year half-life), declining tritium emissions from the Livermore site, and dilution of older ground water with younger recharge water. Tritium in Livermore Valley drinking water is at a very low and safe level, amounting to less than 1% of the MCL. At Site 300 and adjacent properties in the Altamont Hills, ground water monitoring shows that no on-site or off-site drinking water wells were impacted by activities at Site 300 in 1994 and indicate that environmental impacts of both past and present activities are minimal beyond the site boundaries. LLNL will continue to determine the nature and extent of contamination by continued sampling, data analysis, and transport analysis.

Area vegetation and foodstuffs are monitored for their tritium content. The tritium concentrations taken near the Livermore site were greater than those taken from more distant locations. The tritium concentrations were the same as those reported in 1993, within measurement uncertainty. As in the past, the tritium concentrations in Livermore Valley wines analyzed in 1994 are slightly above those for wines tested from Europe and other locations in California; however, even the highest detected value, 8.0 Bq/L (216 pCi/L), is just over 1% of the amount California allows in drinking water. This amount is nearly the same as the highest value for 1993, 8.25 Bq/L (223 pCi/L).

In 1994, soil samples from the Livermore site and Site 300, and arroyo sediment samples from storm water drainage channels at the Livermore site, were analyzed for radionuclides and beryllium. All measured values for 1994 were consistent with historical data and generally showed background values.

LLNL maintains a network of direct radiation monitors, using thermoluminescent dosimeters (TLDs) for gamma radiation. In 1994, TLD measurements at the Livermore-site perimeter averaged 0.72 mSv (72 mrem) and, at the Site 300 perimeter, averaged 0.88 mSv (88 mrem). Both are within the range of background levels for the two sites. The Laboratory also maintained a network of neutron monitors developed at LLNL for neutron radiation, but these monitors have deteriorated. Because neutron measurements for the past decade have shown only background levels, and because data indicate that it is not necessary, neutron monitoring will be discontinued in 1995 to save the cost of replacing the measurement devices.

## Radiological Impact Assessment

The primary DOE radiation standards for protection of the public are 1 mSv/y (100 mrem/y) effective dose equivalent for prolonged exposure, and 5 mSv/y (500 mrem/y) effective dose equivalent for occasional exposure. These limits are based on the dose to the maximally exposed individual in an uncontrolled area, delivered via all pathways. The EPA radiation dose standard, which applies to air emissions only, is promulgated under Section 112 of the Clean Air Act, and defined in Subpart H of the National Emission Standards for Hazardous Air Pollutants (NESHAPs) under 40 CFR 61. It limits to 0.1 mSv/y (10 mrem/y) the whole-body effective dose equivalent to members of the public from airborne releases caused by DOE activities. Additionally, EPA requires continuous monitoring of individual emission points that have potential unabated emissions of 1 μSv/y (0.1 mrem/y) or more.

The EPA NESHAPs standard is small, and the doses caused by radionuclides released from LLNL are smaller still, compared to levels of natural exposure to radioactivity. As a result, it is difficult to use measurements alone to distinguish between LLNL-contributed radiation in the environment and that due to other

sources, to prove compliance with the standard. Therefore, we use mathematical models to calculate potential doses to the public for compliance demonstrations based on measured or calculated releases of radionuclides to air and water. The models implement EPA's approved dosimetry and dispersion models, which contain conservative assumptions that are expected to result in calculated doses larger than ones actually received by members of the public.

Radiological dose-assessment modeling runs using EPA-mandated computer models, actual LLNL meteorology, population distributions appropriate to the two sites, and 1994 radionuclide inventory and monitoring data were conducted for every emission point at the Livermore site and Site 300. The total potential dose calculated for point-source (stack) emissions for a hypothetical person having the greatest possible exposure at the Livermore site in 1994 was 0.42 μSv (0.042 mrem) and, from diffuse-source (area) emissions, was 0.23 μSv (0.023 mrem). Summing these contributions yields a total dose of 0.65 μSv (0.065 mrem) for the Livermore site.

Compared to data of previous years, the total potential dose for 1994 is practically the same as the 1993 value of 0.66 μSv (0.066 mrem), slightly below the 1992 value of 0.79 μSv (0.079 mrem), and well below the dose values of 2.34 μSv (0.234 mrem) and 2.40 μSv (0.240 mrem) reported for 1991 and 1990, respectively. Reduced emissions from the Tritium Facility account for much of this decline.

The dose to a person having the greatest possible exposure at Site 300 during 1994 was calculated to be 0.81 μSv (0.081 mrem). Explosive tests at the Building 801 and Building 851 firing tables accounted for all of the point source dose of 0.49 μSv (0.049 mrem), while a source representing resuspension of both naturally-occurring and LLNL-contributed uranium in surface soils throughout the site was responsible for nearly all of the diffuse sources total of 0.32 μSv (0.032 mrem). In comparison, the Site 300 total dose values in recent years were 0.37 μSv (0.037 mrem) in 1993, 0.21 μSv (0.021 mrem) in 1992, 0.44 μSv (0.044 mrem) in 1991, and 0.57 μSv (0.057 mrem) in 1990.

The doses to the maximally exposed public individual from Livermore site and Site 300 emissions amount to less than 1% of the EPA NESHAPs standard. These doses are a small fraction (about 1/4,000) of the doses received by these populations from natural background radiation. Thus, the potential radiological doses from LLNL operations in 1994 were well within regulatory standards and were very small compared to doses from natural background radiation sources.

## Environmental Compliance Activities

LLNL works to ensure that its operations have limited environmental impacts and comply with environmental laws and federal, state, and local regulatory guidelines. Many activities related to water, air, waste, waste reduction, community "right to know," and other environmental issues were addressed in 1994.

Both the Livermore site and Site 300 are Superfund sites under CERCLA and are undergoing remedial activities. The proposed technique for cleaning up ground water at the Livermore site consists of managed ground water extraction and surface treatment. Contaminated sediments in the unsaturated zone are treated, as appropriate, by extracting fuel hydrocarbons or volatile organic compounds (VOCs) by vacuum-induced venting and treatment of the vapors. EPA and local and state agencies have approved this plan. In 1994, ground water was treated at five facilities to capture and control the off-site spread of contaminated ground water: Treatment Facility A treated more than 87 million liters of ground water, removing and destroying about 5.6 kilograms of VOCs; Treatment Facility B treated about 30 million liters of ground water, removing and destroying about 2.7 kilograms of VOCs; Treatment Facility C treated about 10.6 million liters of ground water, removing 1.2 kilograms of VOCs; and Treatment Facility F treated approximately 15 million liters of ground water, and removed about 300 liters liquid-volume-equivalent of gasoline from the subsurface. Construction of Treatment Facility D was completed on July 13, 1994, and 0.34 million liters of ground water were processed, removing 0.3 kilograms of VOCs.

The Superfund activities at Site 300 are at an earlier stage: LLNL completed a sitewide remedial investigation report during 1994, compiling all ground water and soil investigation information for the entire site, and assessing potential hazards to human health and the environment resulting from contamination of soil, sediment, and ground water. Treatment activities have begun in the General Services Area (GSA) at Site 300. During 1994, 82 million liters of ground water in the eastern GSA were treated to remove about 0.74 kilograms of VOCs. Similar results were obtained in treatments in the central GSA, and proof of system testing was conducted at the Building 834 Complex.

The Laboratory's Chemical Exchange Warehouse (CHEW) program, started in November 1993 with the goal of reducing the disposal of chemicals as hazardous waste, was continued in 1994. This pollution prevention program finds ways of collecting, identifying, storing, and reusing chemicals. Twenty-five percent of the volume of unused chemicals turned into the program is being recycled for additional use.

LLNL continues to perform all activities necessary to comply with clean air and clean water requirements. In 1994, the Bay Area Air Quality Management District issued 71 permits to operate, 396 letters of exemption, and 164 permit renewals for the Livermore site, and conducted five days of on-site inspections. The San Joaquin Valley Unified Air Pollution Control District issued seven permits to operate, two letters of exemption, and 25 permit renewals for Site 300, and conducted three days of on-site inspections. LLNL has permits for discharge of treated ground water, industrial and sanitary sewage, and storm water. Site 300 has additional permits for inactive landfills; cooling tower discharges; operation of the sewer lagoon, septic tanks, and leach fields; and discharge of treated ground water. The Laboratory complies with all requirements for self-monitoring and inspections associated with these permits.

LLNL has one endangered species, *Amsinckia grandiflora* (large-flowered fiddleneck), which is found at Site 300. On April 7, 1994, LLNL personnel counted 1,606 mature plants in the natural population of *Amsinckia*, up from 301 plants observed in 1993. The increase in population is a direct result of the use of grass-selective herbicides to reduce competition from exotic grasses in the area. LLNL personnel also counted 248 mature plants in one of two experimental populations. Work on all populations will continue through 1995.

## Conclusion

LLNL is committed to protecting the environment and ensuring that its operations are conducted in accordance with applicable federal, state, and local laws and regulations. The current techniques used at the Laboratory for environmental monitoring are very sensitive, allowing detection at extremely low levels of constituents. The combination of environmental and effluent monitoring, source characterization, and computer modeling show that radiological doses to the public caused by LLNL operations are less than 1% of regulatory standards and are about 4,000 times smaller than the doses received from background radiation. The analytical results and evaluations generally show a decrease in contaminant levels, reflecting both decreased operations and the responsiveness of the Laboratory in controlling pollutants. In summary, the results of the 1994 environmental monitoring and modeling programs demonstrate that the environmental impacts of LLNL are minimal and pose no threat to the public or the environment.